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Estimation of some Nutrient Values of Quinoa, Chia, Teff, Mung Bean and Buckwheat Seeds for Ruminants by In Vitro Methods

Kinoa, Chia, Teff, Maş Fasulyesi ve Karabuğday Danelerinin Ruminantlar için bazı Besin Madde Değerlerinin İn Vitro Yöntemlerle Tahmini

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Keywords:

Quinoa, chia, teff, mung bean, buckwheat.

ABSTRACT

Objective: The aim of this study was to investigate the availability of quinoa, chia, teff, mung bean, and buckwheat as an alternative feed in ruminant nutrition.

Material and Methods: The materials were composed of quinoa (white, black, red), chia (white, black), teff, mung beans and buckwheat, which have passed their shelf life due to tear or damage in their package. Fatty acid components as well as enzyme soluble organic matter (ESOM) under *in vitro* conditions were also determined in addition to crude nutrient contents. Metabolic energy (ME), using the obtained data, was also calculated.

Results: It was found out that the crude protein (CP) contents were 14.04-15.38% in quinoa, 19.90-21.73% in chia, 11.98% in teff, 25.20% in mung bean, and 13.72% in buckwheat. Ether extract (EE) contents; however, were found out to be 7.13-7.97%, 30.84-35.75%, 2.46, % 3.48%, and 5.25%. The highest amount of linoleic acid was found in chia (60.71-66.17%). ESOM contents was determined at high level in white quinoa, mung bean, and buckwheat. However, *in vitro* ME contents were found at the highest level in chia.

Conclusion: Quinoa has the potential to be an alternative to traditional cereals during early lactation period in ruminant animals, in which energy need is at its highest level, or as a source of energy in fattening period. Chia has a high potential to be effective in preventing heat stress, especially in dairy cattle. The high linolenic acid content of chia oil may allow the milk fat to be enriched by conjugated linoleic acid (CLA), one of the polyunsaturated fatty acids. It has been determined that teff and buckwheat can be alternatives to other cereals, whereas mung bean, due to its crude protein being high and being rich in minerals is a significant alternative for feed producers who have been in search of new sources of protein recently.

Anahtar Sözcükler:

Kinoa, chia, teff, maş fasulyesi, karabuğday.

ÖZ

Amaç: Bu araştırmanın amacı, kinoa, chia, teff, maş fasulyesi ve karabuğdayın alternatif yem ham maddesi olarak ruminant beslemede kullanılabilirliğini araştırmaktır.

Materyal ve Metot: Araştırma materyalini, ambalajın yırtılması, hasar görmesi vb. nedenlerle raf ömrü dolan kinoa (beyaz, siyah, kırmızı), chia (beyaz, siyah), teff, maş fasulyesi ve karabuğday oluşturmuştur. Ham besin madde içeriklerinin yanı sıra yağ asiti bileşenleri ve *in vitro* koşullarda enzimde çözünen organik madde miktarları (EÇOM) belirlenmiştir. Elde edilen verilerden yararlanılarak metabolik enerji (ME) içerikleri hesaplanmıştır.

Bulgular: Ham protein (HP) içeriklerinin kinoada %14.04-15.38, chiada %19.90-21.73, teffde %11.98, maş fasulyesinde %25.20 ve karabuğdayda %13.72 olduğu bulunmuştur. Ham yağ (HY) içerikleri ise sırasıyla %7.13-7.97, %30.84-35.75, %2.46, % 3.48 ve %5.25 olarak belirlenmiştir. En yüksek linolenik asit chiada (%60.71-66.17) belirlenmiştir. EÇOM içeriği beyaz kinoa, maş fasulyesi ve karabuğdayda yüksek bulunmuştur. Oysa *in vitro* ME içerikleri en yüksek chiada belirlenmiştir.

Sonuç: Kinoa, ruminantların enerji gereksiniminin yüksek olduğu erken laktasyon döneminde ya da beside enerji kaynağı olarak geleneksel tahıllara alternatif olma potansiyeli vardır. Chianın özellikle süt sığırlarında sıcaklık stresini önlemede etkili olabilme potansiyeli yüksektir. Chia yağının linolenik asit içeriğinin yüksek olması, süt yağının çoklu doymamış yağ asitlerinden biri olan konjuge linolenik asitçe zenginleşmesine olanak sağlayabilir. Teff ve karabuğday tahıllara, maş fasulyesi ise mineralce zengin olmasının yanısıra HP içeriğinin yüksek olmasından dolayı, özellikle son yıllarda yeni protein kaynakları arayışına giren üreticilere önemli bir alternatif oluşturacağı ortaya konulmuştur.

INTRODUCTION

The aim of livestock enterprises is to make cheap production of good quality by reducing the cost of feed. In ruminant feeds, the major part of the cost consists of sources of energy and protein. The best way of keeping the feed costs at low level is to provide the cheapest feeds, to find alternative sources of feeds, and to optimize the production.

Due to global climate changes, cereal and forage production throughout the world is in distress. Therefore, producers tend to search for alternative feeds. Apart from these, food producers and trading companies do not offer products with torn or damaged packages, spilled or expired products for consumption. Concordantly, large amounts of solid waste occur in the course of time. While the disposal of these wastes cause additional expenses, they, also, lead to environmental problems.

In recent years, the tendency of consumers towards consumption of functional food has increased because of rapid developments in science and technology, the increase of disease treatment expenses, the aging population, the increasing awareness of consumers on the relationship between nutrition and health, and also the changes in food marketing systems (Açıkgöz and Soycan-Önenç 2006). Therefore, every day new functional foods are placed on the shelves in supermarkets. Functional food, especially provided from big supermarket chains (transport, storage, shopworn), lead to large amounts of waste. The use of functional food in animal production, which have hygienic risk for human health, but have no risk for animal health when consumed, makes a great contribution to both production sectors. In addition, their accumulation and waste disposal (mostly burned off) leading to environmental pollution, this also is prevented through their use in the feed production sector. In case of consumption of these products by animals, their level of use and their effect on animals should be known.

Today, functional vegetable foods such as quinoa, teff, mung bean, and buckwheat have come into prominence. Chenopodium quinoa Willd, known as quinoa, belongs to the Chenopodiaceae family, and is a gluten-free annual plant, which has been studied recently for human nutrition and animal nutrition. Studies in our country relating its growth under different conditions (climate, and saline level) and its yield have been conducted since 2012 (Geren et al. 2014, Dumanoğlu et al. 2016).

Chia (*Salvia hispanica*), is a species of the mint family, and is an annual plant. It is mainly grown in countries of Central America such as Mexico and Guatemala. In the past, it had been used by the Mayan and Aztecs in order to increase the performance of soldiers. For the Mayans, Chia meant 'power'. Due to its high energy content, it is known as 'racing food' (Anonymous, 2017).

Teff, which is a drought tolerant and also a warm-season plant, can be harvested multiple times during vegetation period, and is mainly used as animal feed in countries like Australia, South Africa, and the United States (Baye, 2014). Due to the crude protein contents and metabolic energy of teff grass being high at its pre-bloom or blooming periods, it is advised for grazing, or its use in ruminant nutrition as dry hay (Kaplan et al. 2016). Moreover, in a study conducted in Aydın, Turkey, it has been concluded that teff can be harvested twice for grain production, and three times for dry hay production (Geren et al., 2019).

Mung bean [V*igna radiata* (L.) Wilczek] has been grown in India since ancient times (Oplinger et al. 1990). It is a legume, belongs to the family of cowpea, but differs as species. It is a warm-season plant, and is adapted to the same climatic conditions with soy bean and cowpea. The sprouted mung bean seeds are used as food. Sprouts of mung beans are rich in protein (21-28%), calcium, phosphorus, and in some vitamins (Dalkılıç, 2010).

This study was planned in order to investigate the possibility of use of quinoa, chia, teff, mung bean, and buckwheat, which expired due to tear or damage of their package, etc. in ruminant nutrition as an alternative feed.

MATERIAL and METHOD

The feed materials for the study consisted of quinoa (white, black, red), chia (white, black), teff, mung bean, and buckwheat, which expired due to reasons such as tear or damage of their package.

The dry matter (DM) was determined by drying the samples at 105 °C for 16 h. Crude protein (CP), ether extract (EE), crude fibre (CF) and crude ash (CA) contents were determined through weende analysis method (Bulgurlu and Ergül 1978), and starch (polysaccharide) was determined according to Turkish Standard Institute (TSI) 2000. Nitrogen-free extract (NFE) and sugar were determined via differential method of measurement. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) contents, which are components of the cell membrane of the samples, were determined according to the method stated by Van Soest et al. (1991). Hemicellulose and cellulose (Close and Menke 1986) was determined by calculation. Enzimatic solubility of organic matter was determined with the procedure reported by Nauman and Bassler (1993). In the technique, pre-treatment with pepsin-hydrochloric acid solution, followed treatment by cellulase (Onozuka R 10 from *Trichoderma viride,* Merck) .

Crude oil was obtained through ether extraction, and it was transformed into fatty acid methyl esters according to AOCS (Ce 2-66) method (Anonymous, 1992). Fatty acid methyl esters were determined using SHIMADZU 2010 Gas Chromatography (GC) tool and flame-ionisation detector (FID). TR-CN 100 (0,25mm x100m x 0,2mm) capillary column was used in the analysis. Inlet temperature was set at 250 °C. Column furnace temperature starting at 100°C was elevated 3°C/min. up to 240°C, with a waiting period at 240°C for ten minutes for 60 minutes. The temperature of the injection and detector were 250, split rate was 1:100, and injection volume was 1µl. Helium with a flow rate of 30ml/min was used as the carrier gas.

Metabolizable energy value estimation

In vitro ME contents in examples were calculated using crude nutrient components (CNC), NDF, ADF, ADL and ESOM determined because of chemical analysis according to the equation given below:

ME_{CNC} kcal/kg OM*= 3260 + (0.455 x CP* + 3.517 x EE*) – 4.037 x CF* (Anonymous, 1991), (*in Organic matter (OM) g/kg).

ME_{NDF}, kcal/kg DM=3381.9-19.98 x NDF* (Kirchgessner et al., 1977).

ME_{ADF}, MJ/kg DM= 14.70-0.150 x ADF* (Kirchgessner and Kellner, 1981).

ME_{ADL}, kcal/kg DM=2764.4-102.73 x ADL* (Kirchgessner et al., 1977).

***** NDF, ADF and ADL in %**,** ME contents were translated into kilocalories.

ME_{ESOM}, MJ/kg DM=12.6 CP+22.5 CF+11.2 NFE + 0.3975 CA x EE – 0.1993 CA x CF + 0.2449 $ESOM^2$ – 150) x 10^{-3} (Jeroch ve ark. 1999).

*(CP, NFE, EE, CF, CA g/kg; ESOM in g/kg DM).

Statistical Analyses

Data obtained as a result of this study were evaluated according to the analysis made through SPSS v.18 package programme (SPSS 2009). Duncan test was used for the comparison of ensemble average. Statistical analysis revealed that palmitic acid (C16: 0), stearic acid (C18: 0), oleic acid (C18: 1 cis), linoleic acid (C18: 2 cis) and linolenic acid (C18: 3), which constitute a significant part of the fatty acid compositions of the samples.

RESULTS

Crude nutrient contents of quinoa, chia, teff, mung bean, and buckwheat, which were used in the study are given Table 1.

When analysed statistically, it was found out that they differ in terms of crude nutrient contents (P<0.01). Crude protein, EE, CF, and CA in white, black, and red quinoa were determined as 15.01 %, 7.68, 3.30, 2.69; 15.38 %, 7.13, 7.88, 2.76; 14.03 %, 7.97, 5.59, 2.55 respectively. These values in white and black chia were found out as 19.90 %, 30.84, 20.95, 4.99; 21.73 %, 35.75, 17.26, 5.11 respectively; the values of teff were 11.98%, 2.46, 3.44, 2.26, they were found out as 25.20 %, 3.48, 5.58, 4.19 in mung beans, and these values were 13.72 %, 5.25, 1.37, 2.10 in buckwheat. It was determined that the highest starch content was in teff and buckwheat (P<0.01). The rest of nitrogen-free extract contents, which were calculated through the subtraction of starch from NFE were found out to be the highest in white chia and red quinoa (P<0.01). While the highest NDF and ADF were determined to be in white (40.74% and 29.76%) and black chia (32.47 and 24.36), the lowest NDF was found in teff (20.22%), and the lowest ADF was determined as 2.47% in buckwheat (P<0.01).

Table 1. Crude nutrient and cell wall contents of samples, in DM %
Çizelge 1. *Örneklerin ham besin maddesi ve hücre çeperi içerikleri, % KM*

Sample	DM	CA	CP	EE	CF	NFE		NDF	ADF	ADL	Hemicellulose	Cellulose
						Starch	Rest					
WQ	93.09±0.03^{b}	2.69±0.01^{cd}	15.01±0.02^{e}	7.68±0.01^{d}	3.30±0.04^{e}	58.85±0.05^{c}	12.46±0.07^{g}	22.29±0.01^{g}	2.67±0.08^{f}	1.78±0.02^{g}	19.62±0.08^{b}	0.90±0.01^{h}
BQ	93.13±0.02^{b}	2.76±0.03^{c}	15.38±0.06^{d}	7.13±0.06^{e}	7.88±0.05^{c}	48.66±0.02^{e}	18.17±0.05^{c}	29.12±0.01^{d}	11.41±0.07^{c}	3.87±0.02^{c}	17.71±0.07^{c}	7.55±0.09^{c}
RQ	92.64±0.06^{c}	2.55±0.07^{d}	14.03±0.08^{f}	7.97±0.01^{c}	5.59±0.02^{d}	51.27±0.03^{d}	18.59±0.10^{b}	23.21±0.09^{f}	8.17±0.02^{d}	3.25±0.06^{d}	15.04±0.08^{e}	4.92±0.08^{e}
WC	96.13±0.08^{a}	4.99±0.06^{a}	19.90±0.07^{c}	30.84±0.02^{b}	20.95±0.05^{a}	2.49±0.01^{g}	20.85±0.11^{a}	40.74±0.11^{a}	29.76±0.05^{a}	9.09±0.05^{b}	10.98±0.06^{g}	20.67±0.09^{a}
BC	96.04±0.05^{a}	5.11±0.09^{a}	21.73±0.02^{b}	35.75±0.06^{a}	17.26±0.17^{b}	2.37±0.06^{h}	17.77±0.29^{d}	32.47±0.11^{b}	24.36±0.05^{b}	11.30±0.22^{a}	8.12±0.09^{h}	13.05±0.07^{b}
Teff	93.23±0.06^{b}	2.26±0.01^{e}	11.98±0.01^{h}	2.46±0.07^{h}	3.44±0.05^{e}	65.99±0.01^{a}	13.87±0.13^{f}	20.22±0.01^{h}	5.98±0.03^{e}	3.09±0.08^{e}	14.24±0.04^{f}	2.89±0.05^{f}
MB	92.71±0.01^{c}	4.19±0.08^{b}	25.20±0.03^{a}	3.48±0.09^{g}	5.58±0.02^{d}	47.72±0.02^{f}	13.83±0.05^{f}	23.93±0.05^{e}	8.11±0.04^{d}	2.84±0.08^{f}	15.82±0.09^{d}	5.27±0.04^{d}
BW	90.47±0.05^{d}	2.10±0.02^{f}	13.72±0.03^{g}	5.25±0.07^{f}	1.37±0.02^{f}	62.24±0.02^{b}	15.32±0.09^{e}	31.29±0.08^{c}	2.47±0.04^{g}	1.30±0.02^{h}	28.82±0.12^{a}	1.17±0.05^{g}
P values	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

WQ: White quinoa, BQ:Black quinoa, RQ:red quinoa, WC:White chia, BC:Black chia, Mung bean, BW:Buck whheat, DM: Dry matter, CA: Crude ash, CP: Crude protein, EE: Ether extract, CF: Crude fiber, NFE: Nitrogen-free extract, Rest:NFE-starch, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, ADL: Acid detergent lignin. ± SEM, standart error of means, ^{abc}: Means with different letters in the same column are statistically significant (P<0.01).

Table 2. Fatty acid components of samples, %
Çizelge 2. *Örneklerin yağ asidi bileşenleri, %*

Fatty acid	WQ	BQ	RQ	WC	BC	Teff	MB	BW	P
Palmitic acid, C16:0	9.24±0.02^{d}	9.22±0.06^{d}	9.91±0.07^{c}	7.23±0.05^{e}	6.88±0.06^{f}	13.44±0.07^{b}	26.76±0.06^{a}	13.61±0.01^{b}	<0.001
Stearic acid, C18:0	0.82±0.01^{f}	0.74±0.03^{fg}	0.60±0.01^{g}	3.62±0.01^{b}	2.72±0.06^{d}	3.33±0.06^{c}	4.38±0.01^{a}	1.57±0.05^{e}	<0.001
Oleic acid, C18:1	26.97±0.04^{d}	27.44±0.03^{c}	25.44±0.05^{e}	7.18±0.01^{f}	5.68±0.05^{g}	27.86±0.06^{b}	1.82±0.04^{h}	38.82±0.07^{a}	<0.001
Linoleic acid, C18:2	52.70±0.01^{a}	51.96±0.04^{b}	52.74±0.03^{a}	21.23±0.02^{f}	18.56±0.03^{g}	47.05±0.04^{c}	39.23±0.07^{d}	36.80±0.07^{e}	<0.001
Linolenic acid, C18:3	5.84±0.03^{g}	6.55±0.06^{f}	7.57±0.06^{e}	60.75±0.07^{b}	66.19±0.02^{a}	8.31±0.06^{e}	20.84±0.04^{c}	5.34±0.07^{h}	<0.001
Araşidic acid, C20:0	-	-	-	-		-	1.7148	1.3125	-
Araşidonic acid, C20:4	2.3402	2.3024	2.2892	-		-	-		-
Behinic acid, C22:0	0.7667	0.4948	-	-		-	3.5361	1.5131	-
Erusic acid, C22:1	1.3033	1.3714	1.3989	-		-	-	-	-
Lignoseric acid, C24:0	-	-	-	-		-	1.7694	0.9379	-

WQ: White quinoa, BQ: Black quinoa, RQ:red quinoa, WC: White chia, BC:Black chia, MB:Mung bean, BW:Buck wheat, ± SEM, standart error of means, ^{abc} Means with different letters in the same line are statistically significant (P<0.01).

When fatty acid compound was investigated, it was found out that all three types of quinoa had the highest level of linoleic acid (P<0.01), followed by oleic acid (Table 2), that linolenic acid contents were high in both types of chia (P<0.01), and also it was determined that mung bean, teff, and buckwheat had high linoleic acid amounts just as the quinoa types.

Table 3. ESOM (DM %) and ME (kcal/kg DM) contents of samples
Çizelge 3. *Örneklerin EÇOM (% KM) ve ME (kcal/kg KM) içerikleri*

Sample	ESOM	*ME_{ESOM}	ME_{CNC}	ME_{NDF}	*ME_{ADF}	ME_{ADL}
WQ	94.37±0.09[a]	2640.6±0.71[e]	3377.4±2.16[c]	2936.5±0.22[b]	3415.9±2.99[b]	2581.9±1.98[b]
BQ	82.14±0.15[f]	2720.4±0.73[c]	3172.3±3.80[f]	2800.0±0.07[e]	3102.7±2.41[e]	2367.3±2.11[f]
RQ	85.24±0.10[e]	2675.9±1.73[d]	3295.1±2.26[d]	2918.2±1.78[c]	3219.0±0.59[d]	2430.6±6.62[e]
WC	40.38±0.14[g]	3302.3±10.33[b]	3427.1±3.11[b]	2567.9±2.29[h]	2445.4±1.81[g]	1830.7±5.0[g]
BC	36.60±0.19[h]	3429.6±22.53[a]	3752.9±8.36[a]	2733.1±2.17[g]	2638.9±1.89[f]	1603.1±2.28[h]
Teff	86.24±0.08[d]	2655.7±0.72[de]	3188.7±1.38[e]	2977.9±0.26[a]	3297.4±1.05[c]	2447.4±8.03[d]
MB	92.85±0.17[b]	2683.2±2.19[d]	3135.3±6.04[g]	2903.7±1.06[d]	3221.0±1.33[d]	2472.6±7.71[c]
BW	90.93±0.12[c]	2605.7±0.46[f]	3383.4±2.21[c]	2756.8±1.65[f]	3423.2±1.36[a]	2630.8±1.62[a]
P values	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

WQ: White quinoa, BQ: Black quinoa, RQ: Red quinoa, WC:White chia, BC:Black chia, MB: Mung bean, BW:Buck wheat, ESOM: Enzyme soluble organic matter± SEM, standart error of means, [abc:] Means with different letters in the same column are statistically significant (P<0.01). * ME contents were translated into kilocalories.

While the highest ESOM contents (Table 3) were determined to be in white quinoa as 94.37%, in mung bean as 92.85%, and in buckwheat as 90.93%; the lowest ESOM contents were found out to be in black (36.60%) and white (40.38%) chia (P<0.01). In both types of chia, ME_{ESOM} and ME_{CNC} values related to CF contents were found out to be high. However, in the equation based on NDF (ME_{NDF}), teff takes the first place (P<0.01).

DISCUSSION

Quinoa is known to have 125 different varieties of seeds. Although they have a colour scale changing from green to grey, the commercial ones introduced in supermarkets in Turkey are the white, black and red ones. In the research conducted has concluded that crude protein was found out the highest in mung bean, both chia, white, black, and red quinoa seeds compared to many crops; however lower than legumes. The interest in quinoa, which can be grown in various geographical conditions and altitudes due to its wide adaptation ability in terms of climate and soil, has risen dramatically. In studies carried out in our country, it was reported that CP contents of quinoa seeds in the dry conditions of Iğdır plain were between 9.83% and 4.64% (Kır and Temel 2016), and that in different saline density it changed between 10.8% and 18.5% (Dumanoğlu et al. 2016). In this study it was determined that CP contents of quinoa were above the ones reported by Kır and Temel (2016), while in different saline density was within the values reported by Dumanoğlu et al. (2016). Compared to cereal grains, CP and EE contents of quinoa seeds are higher than that barley (11.16, 2.37 %), sorghum (9.66, 3.43 %) and corn (8.71, 3.36 %) (Baran et al. 2008). It was concluded that in another geographic region, 6 ecotype quinoas contained 5.88-7.15% EE, 1.33-2.81% CF and 56.73-68.36 % total carbohydrate (Miranda et al. 2012). Moreover, it was also stated that quinoa flour is a valuable source containing significant antioxidant activity and components (Pellegrini et al. 2018). In our study, it was determined that EE contents of quinoas were similar to those found by Miranda et al. (2012), but CF contents were below (9.5% CF) the results of Ogunbenle (2003).

Chia seeds contained 24% protein, 25-35% oil and 22% CF, and were also particularly rich in unsaturated fatty acids (Silva et al. 2016a). In a research, it was determined that the addition of chia seed into the ration had no negative effect on rumen fermentation, digestibility, microbial activity and rumen nitrogen (N) metabolism (Silva et al. 2016b). Due to being rich in Omega-3 fatty acid, the addition of chia seeds into the ration may change the fatty acid composition of meat and milk (Silva et al. 2016b). In our study, it was determined that the EE contents of white and black chia were similar to those found out by Silva et al. (2016a), but below the values of CP and CF contents.

When compared with barley, which is a traditional cereal, in our study, it was found out that, except for teff and buckwheat, CP was higher than that in barley (Baran et al. 2008, Abaş et al. 2005); however NFE was determined to be high in teff, but in white and black chia it was found out to be significantly low. Baye (2014) stated that the CP and starch, and CF contents in teff were found similar to corn, sorghum and wheat, which are traditional cereals used in animal nutrition. In our study, CP and CF contents in teff were found out to be higher than those in the study conducted by Baye (2014), whereas their starch contents were determined as low.

It was concluded that tartary buckwheat was a satisfactory grain substitute for ruminant animals and had about 85% of the digestible energy content of barley (Nicholson et al. 1976).

Quinoa can be considered an alternative oil seed crop, due to the quality and quantity of its lipid fraction. The fatty acid composition in quinoa oil is similar to that of maize and soybean oil. Unsaturated fatty acids in quinoa oil reach up to 85% of the total fatty acid (Jahaniaval et al. 2000). The main component in quinoa oils of three different colours was determined linoleic acid (51.98-52.72 %), followed by oleic acid (25.48-27.41%), linolenic acid (5.82-7.5 %) and palmitic acid (9.22-9.99%). These results agree with the fatty acid amounts in quinoa oil found by other authors (Peiretti et al. 2013, Pellegrini et al. 2018). However, this study was found that all quinoas contain 1.3-1.4 2% erucic acid. These results are consistent with other studies (Peiretti et al. 2013, Pellegrini et al. 2018; Vera et al. 2019).

Erucic acid is present in food and feed, predominantly as component of triacylglycerols. It is well absorbed from the gastrointestinal tract to an extent varying between 60% and 100%, depending on the species. Humans exhibit virtually complete absorption. Erucic acid is distributed to all organs; however, there is little distribution into the brain. Mitochondrial b-oxidation of erucic acid is poor in rats and pigs. Human heart mitochondria appear to also have low activity for erucic acid. Little is known regarding the excretion of erucic acid. Only older studies are available which have focussed on measuring the faecal excretion of erucic acid (Ziemlanski et al. 1973).

Quinoa is, also, an excellent example of 'functional food' which may help reduce the risk of various diseases. Its functional properties may be related to the presence of fibres, minerals, vitamins, fatty acids, antioxidants and phytonutrients, which favourably contribute to human nutrition. Quinoa contains a number of nutrients including oil with higher levels of essential fatty acids that have a beneficial effect on human health (Maradini-Filho 2017). Grains and grain-based products contain in general low concentrations of erucic acid. Relatively high concentrations of erucic acid (up to 1,066 mg/kg) have been also reported for quinoa seeds. Although quinoa is not a cereal, as it belongs to the Amaranthaceae family, the seeds have similar uses as cereals and they are accordingly considered as pseudo cereals. Quinoa is one of the few plant species out of the Brassicaceae family that can accumulate erucic acid in the seed, with a level typically below 2% of the total fatty acids (Wood et al., 1993). In this study, it was found that all quinoas contain less than 2% erucic acid. There is evidence that erucic acid in the feed is transferred to products of animal origin and a dose-related increase in erucic acid in food of animal origin has been shown. In ruminants, erucic acid is, also, partially hydrogenated or isomerised in the rumen (EFSA 2016).

Many studies have been reported in which the effects of erucic acid intake by farm and companion animals and fish have been examined. However, interpretation of the results is difficult because the level of erucic acid has not been reported, and/or because where adverse effects have been reported they may be confounded by the presence of other antinutritive factors in meal, particularly glucosinolates. Data on human dietary exposure levels of erucic acid across dietary surveys and age groups showed that range from 0.3 to 4.4 mg/kg body weigth per day A tolerable daily intake of 7 mg/kg body weight per day for erucic acid was established and mean chronic exposure of the different groups of the population did not exceed the total dietary intake (EFSA 2016).

Nitrayová et al. (2014) concluded that there was 63.79 % linolenic acid and 18.89% linoleic acid in chia oil. In the study conducted, linolenic acid ratio in black chia was found out to be above the findings; however, in white chia, it was determined to be below the findings of Nitrayová et al. (2014). Moreover, it was stated that chia oil cake is a good source of protein (19.0-23.0%) and fiber (33.9-39.9%), and also that it contains antioxidant (Silva et al. 2016a). When research results were evaluated, it was determined that the findings of our study were similar to those of Silva et al. (2016a).

It was stated in a research that phospholipids and triglycerides were at high level in mung bean, and also that the dominant fatty acids were linoleic acid and oleic acids (Zia-Ul Hag et al. 2008). In our study it was determined that similarly to the study conducted by Zia-Ul Hag et al. (2008), linoleic acid ratio was high

(39.23%), oleic acid was low (1.82 %), and that palmitic acid (26.76 %) and linolenic acid (20.84%) ratios were high. In our study, it was found out that EE amount of teff (2.46%) was similar to that of Baye (2014), and that fatty acid components were high. In their studies, Gülpınar et al. (2012) and Peng et al. (2017) similarly this study stated that oleic acid and linoleic acid amounts in buckwheat seeds were at high level.

The energy, which is provides by feed stuff or feedmix for the metabolism events of an animal, is essential in the estimation of the value of the feed. Since animal metabolism need energy in activities such as vital body functions, tissue renewal, synthesis of meat, milk and eggs, and the activities of the animal, the energy content of the feed is an essential measure of the feed value. On the other hand, since the price of cereals are determined according to their energy concentration, it is essential to know the energy contents of the feed stuff in order to be able to prepare economic rations which lead to profitable production (Denek and Deniz 2004).

In this study, the energy contents of the feeds were determined using various equations. Thus, ME contents varied according to the amount of nutrients used in the equation. In our research, it was found out that ESOM, ME_{NDF} and ME_{ADF} contents decreased in inverse proportion with the increase of NDF and ADF contents, and that the lowest ESOM, ME_{NDF} and ME_{ADF} were determined in both chia varieties. Van Soest (1994) and Yavuz (2005) stated in their studies that the increase of NDF and ADF, which are present in feeds and slow down digestion, leads to the feeling of fullness, and thus limits the feed consumption. When the results obtained were evaluated, although the digestibility of chia by ruminants was low, the highest determination of ME_{ESOM} content in white and black chia can be explained through regression equations. Thus, since the energy content of feed is obtained through the multiplication of digestible nutrients with particular coefficients, there is a positive correlation between the energy value and the digestible nutrients of the feed (Denek and Deniz 2004). Therefore, while the ADF contents were found out to be high and ESOM contents to be low in white and black chia, ME_{ESOM} was determined to be high due to EE contents. While the highest ESOM contents were determined in mung bean, white quinoa, and buckwheat, ME_{ESOM} was also expected to be high; however, the results were not as expected.

It is known that today quinoa, chia, teff, mung bean and buckwheat are widely used in human nutrition. However, the use of these crops is limited in animal nutrition. In this study, besides CP contents of white, black and red quinoa being higher than those of gramineae, their EE contents were also high, and this resulted in higher ME values calculated from the ME equation for ruminants according to TSI. The ESOM content, which was determined via cellulase technique, was also found out to be high. Quinoa can be used as an alternative to traditional cereals as an energy source during early lactation period or fattening period, when ruminants have high energy requirements. Particularly due to their linoleic acid amounts being high, their use in the fattening period, it will affect the meat quality positively. It will enable the meat to be rich in CLA.

The CA contents of white and black chia being high, reveals that they are rich in minerals. At the same time, their CP, EE contents being high, resulted in their ME contents also being high. However, their ESOM contents were found out to be very low. The reason was that NDF, and particularly their ADF were at high level. Their oil content being high may also be effective in heat stress prevention in dairy cattle. When fatty acid components are analysed, linolenic acid being high, will increase the polyunsaturated fatty acids and especially conjugated linoleic acid contents of milk fat. Thus, the functionality of milk will increase. When the results obtained from the research are evaluated together, it is concluded that mung bean is an alternative protein source, and teff and buckwheat are new alternatives to cereals.

CONCLUSION

This laboratory study concluded that quinoa, chia, teff, mung bean and buckwheat, which have passed their shelf life due to damage in their package in supermarkets or storehouses, can be used as an alternative feed source in ruminant nutrition based on the chemical analysis and calculations.

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